Unit 1: Atomic Structure and Electron Configuration

Molar Mass

Avogrado's number: $6.02 * 10^{23}$, which indicates the particles in a mole of any substance.

Molar Mass: used to refer to the mass of all the molecules in any substance in moles.

Mole: a unit that which measures quantity; 1 mole is equivalent to $6.02 * 10^{23}$

Percent Composition: Percent by mass of each element in the compound

- 1 mole of *any element* = $6.02 * 10^{23}$ atoms
- 1 mole = element's average atomic mass in grams from the periodic table
    - Ex. I mol of potassium = $6.02 * 10^{23}$ atoms or 39.1 grams K
- 1 mole of any *molecular compound* = $6.02 * 10^{23}$ moles
- 1 mole of any *ionic compound* **=** $6.02 * 10^{23}$ (formula units)
    - **GFM**: Gram formula mass; the mass of one ionic compound
    - Ex. 1 mol of NaCl = 58.5 grams NaCl
- 1 mole of any *gas* = 22.4 Liter

When masses of atoms, molecules and formula units are measured in grams they are termed as:

- **GAM: Gram Atomic Mass**
    - Ex. 1 mol of Carbon = 12.01 grams
- **GMM: Gram Molecular Mass**
    - Ex. 1 mol of H_2O = (1.01 * 2) + (16.00) = 18 grams
- **GFM: Gram Formula Mass**
    - Ex. 1 mol of NaCl = 58.5 grams of NaCl

Formulas and Calculations

Molar Mass = mass (in grams) / moles

- Ex. Calculating the molar mass of a substance if 0.235 moles of the substance has a mass of 45.67 grams.
  - Molar Mass = 45.67 grams / 0.235 moles = 194 g/mol

Percent Composition

- **Mass percent** = total molar mass of an element / molar mass of the whole compound *100%
  - Ex. What is the percent composition by mass of Hydrogen in H_2O
    - Molar mass of H_2 = (1.01 * 2) = 2.02 grams
    - Molar mass of H_2O = (1.01 * 2) + (16.00) = 18.02 grams
    - 2.02/18.02 * 100% = 11.2 % percent composition of H_2

Atomic Structure and Electron Configuration

Atomic Number: The number of protons in an atom. The periodic table is arranged by increasing atomic number.

Atomic Mass: The mass of a single atom of an element expressed in atomic mass units (amu).

Electron: Negatively charged particle that is outside the nucleus of a model.

Ion: Atom that has a positive or negative charge, due to an imbalance in the number of protons and electrons

Isotope: An element whose atoms have different numbers of neutrons, but keep the same number of protons.

Neutron: A subatomic particle that has no charge and is in the nucleus.

Nucleus: The positively charged dense center of the atom

Proton: a subatomic particle that has a positive charge and is in the nucleus

Wavelength: Distance between corresponding points of two consecutive waves

Evolution of Atomic theory

John Dalton (1808)

- Said that elements are made of atoms, and compounds are formed by combining elements in *fixed* ratios

J.J. Thompson (1898)

- Realized that the beam produced was negative while working with Cathode Rays
- He was able to measure the charge:mass ratio but not individual quantities
- Made the plum pudding model which shows that negatively charged electrons are stuck on a positive cloud

Robert Millikan (1909)

- "Oil Drop Experiment" : He injected drops of charged drops of oil into an electric field and further explained J.J. Thompson's answers
- Determined the electron's charge to be 1.6 x 10^{-19} C.

Ernest Rutherford (1911)

- "Gold Foil Experiment" : He fired a beam of alpha particles at gold foil
    - He expected the alpha particles all to go through and most of them did but a few bounced back
    - He concluded from the experiment that a small, dense, positive nucleus is in the center of the atom and the electrons must move around it at a large radius

Max Planck

- Said that light could only be emitted in certain energies, which was introduced as quantized energy
- Delta E = nhv or E = hv
    - E = energy of photon (light wave)
    - V = frequency (hz)
    - H = planck's constant: 6.626 * 10^{-34} J/Hz
    - n = a whole number

Albert Einstein (1905)

- Said that energy and mass (matter) are interchangeable; they are different forms of the same thing
- Theory of relativity: $E = mc^2$
    - E= Energy
    - M = mass

    - C = speed of light

Louis de Broglie (1923)

- He stated that particles behave like waves
- Lambda = h/mv
    - Lambda = wavelength
    - H = planck's constant in J/Hz
    - M = mass of the particle
    - V = velocity

Neils Bohr (1913)

- Said that the emission spectrum of hydrogen made only a few bright lines, not a full spectrum.
- He stated based on his observations that electrons jumping around energy levels create those lines.
- Electrons move around the nucleus in a certain circular orbit
    - Energy available to the electron: $E = -(2.178 * 10^{-18} J)(z^2/n^2)$
        - Z = atomic number
        - N = energy level (orbit radius #)
        - Negative sign = the lower the n (the closer to the nucleus) the more negative E is
- Disadvantage: Bohr's model doesn't work for atoms other than hydrogen and electrons don't actually move in an circular orbit

Isotopes

- Atoms of the same element with different mass numbers (due to different number of neutrons)

Formation of ions

- When an atom gains or loses electrons, an ion is formed.
- Electron is gained = negative ion
- Electron is lost = positive ion

Wavelength

Frequency = # of waves that pass a certain amount of time

Amplitude = maximum amount of displacement of a particle on the medium from its rest position

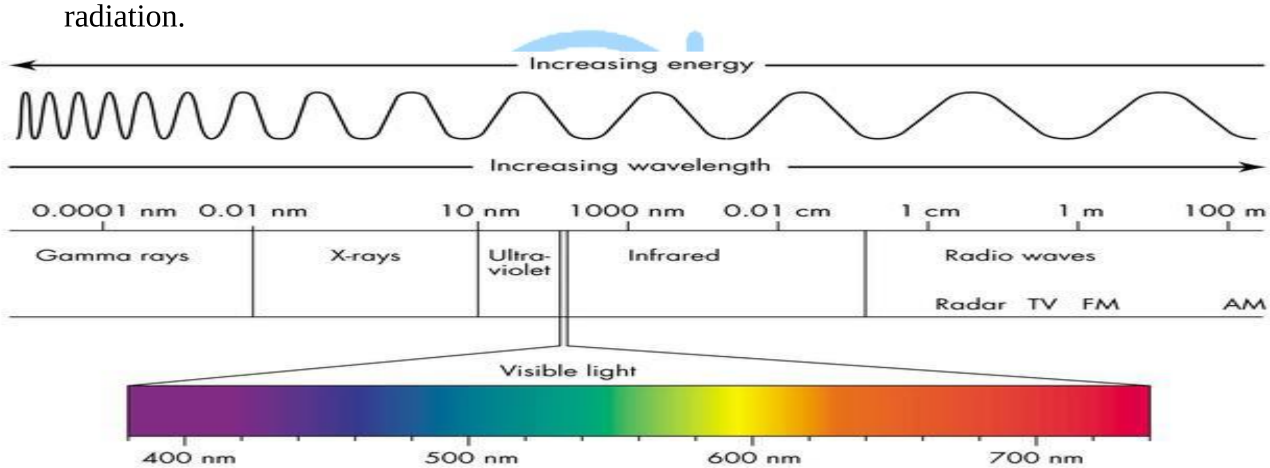
Speed of light = C = $3.0 * 10^8$ m/sec

Wavelength denoted by lambda

- **Longest wavelength** = long wave radio = least energy (red)
- **Shortest wavelength** = Gamma rays = most energy (violet)

Important relationships

- The longer the wavelength, the lower the frequency (inverse relation)
- The higher the frequency, the higher the energy (direct relation)
- The higher the wavelength, the lower the energy (inverse relation)
- The Electromagnetic Spectrum showcases the different ranges of electromagnetic radiation.



Electron Configuration/Orbitals

Energy sublevel and what it looks like	Orbitals	# of Electrons
S (Sphere)	1 (0)	2

P (Propeller)	3 (-1,0,1)	6
D (Double Dumb bell)	5 (-2,-1,0,+1,+2)	10
F (Frenzy)	7 (-3,-2, -1, 0, 1, 2, 3)	14

Type of orbital	What it's used for	More information
N	• Principle energy used • As n increases, energy increases the distance from the nucleus	Specifies the **energy** of an electron and the **size** of the orbital All orbitals that have the same value of *n* are said to be in the same **shell** (**level**).
L	Energy sublevel	(0,1,2,3) (s,p,d,f)
M_s	spin	• Positive, up arrow ½ • Negative, down arrow 1/2

M	Orbital (direction in space)	• 0,0 • -1,0,1 • -2,-1,0,1,2 • -3,-2,-2,0,1,2,3

Websites that I referenced:

- https://courses.lumenlearning.com/boundless-chemistry/chapter/molar-mass/
- https://www.chem.fsu.edu/chemlab/chm1045/e_config.html

Picture:

- https://sites.google.com/a/coe.edu/principles-of-structural-chemistry/relationship-between-light-and-matter/electromagnetic-spectrum